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**Voltage responsive display appts. - has control and voltage dividing electrodes mounted on respective insulating cover plate closing container ends**
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Inventor: BLUNT R T
Number of Countries: 001 Number of Patents: 001
Patent Family:

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| GB 1507832 | A | 19780419 | | | | 197816 B |

Priority Applications (No Type Date): GB 7453820 A 19741212

Abstract (Basic): GB 1507832 A
The voltage responsive display appts. employs an electrophoretic suspension in a cavity bounded by a transparent wall, or walls, and has voltage applying electrodes in the cavity. The appts. includes a container (8) with end cover plates (9) and (10) all of an insulating material and the cover plates transparent. A control electrode of low resistance (11) is mounted on the inner wall of the first plate (9), with a voltage dividing electrode (12) mounted on the other plate.
The voltage dividing electrode has a relatively high resistance with a voltage to be indicated applied across this electrode. An electrophoretic suspension (6) fills the space between the electrodes with the level at which the appearance of the suspension changes indicates the value of the applied voltage.
Title Terms: VOLTAGE; RESPOND; DISPLAY; APPARATUS; CONTROL; VOLTAGE; DIVIDE ; ELECTRODE; MOUNT; RESPECTIVE; INSULATE; COVER; PLATE; CLOSE; CONTAINER; END
Derwent Class: S02
International Patent Class (Additional): G01D-001/16; G01D-007/00
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## (54) VOLTAGE SENSITIVE DISPLAY APPARATUS


(71) We, THE PLESSEY COMPANY LIMITED, a British Company of 2/60 Vicarage Lane, Ilford, Essex do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—


This invention relates to voltage sensitive display apparatus.

The invention provides a voltage sensitive display apparatus comprising an electrophoretic suspension medium sandwiched between a first potential dividing electrode and a second control electrode at least one of which is transparent, in which at least the potential dividing electrode is fabricated from a resistive material and in which terminals are provided for the application of a potential across the resistive material.

The two electrodes between which the electrophoretic suspension medium is sandwiched are each mounted on a respective support member and at least one of the electrodes and the associated support member are arranged to be transparent, the transparency of the or each electrode being effected by reason of its thinness or by reason of its inherent material characteristics or by reason of its construction.

The apparatus may be in the form of a striplike sandwich construction which is relatively narrow in width compared with its length.

The apparatus according to the invention may have both of the electrodes of conductive resistive material, and according to one embodiment of the invention the apparatus may have one of the electrodes of relatively low electrical resistance and the other electrode of somewhat higher resistivity material having terminal means at each end thereof between which a first potential gradient can be established, the optical characteristics of the electrophoretic suspension medium altering in dependence upon the variation in magnitude and direction of a second potential gradient which exists between the two electrodes.

The foregoing and other features according to the invention will be better understood from the following description with reference to FIGURES 2 to 5 of the drawings accompanying the provisional specification, in which:

FIGURE 2 diagrammatically illustrates in a cross-sectional side elevation an electrophoretic display apparatus according to the invention,

FIGURE 3 illustrates the electrical equivalent of one of the electrodes of the apparatus according to FIGURE 2,

FIGURE 4 illustrates a graph of the voltage gradient across one of the electrodes of the apparatus according to FIGURE 2, and

FIGURE 5 diagrammatically illustrates in a front elevation one arrangement for the apparatus of FIGURE 2.

A voltage sensitive display apparatus according to the invention is diagrammatically illustrated in FIGURE 2 of the drawings and includes an electrophoretic suspension medium 6 enclosed in a housing 7 consisting of a hollow electrically insulating open-ended container 8 closed at each end by electrically insulating members 9 and 10, for example of glass, polyester, cellulose acetate, regenerated cellulose or polyethylene. Electrodes 11 and 12 are respectively attached to the inner surfaces of the members 9 and 10 and are in contact with the suspension medium 6. The electrode 11 being known as the control electrode has a relatively low resistance and the electrode 12 being known as the potential dividing electrode has a relatively high resistance typically in the range 10 to $10^6$ ohms/square. At least one of the members 9 and 10 and its associated electrode will be transparent.

The electrophoretic suspension medium 6 includes a dispersion of finely divided particles *6a* of an opaque dielectric material suspended in a coloured, essentially non-conducting, suspension liquid *6b*. The particles *6a* are shown greatly enlarged for the sake of clarity, but, in practice, it is thought that the particles *6a* must not be greater than about 1/10th of the spacing between the electrodes 11 and 12. In a practical arrange-

ment the spacing between the electrodes 11 and 12 could be about 0·0015 inches.

It will be assumed by way of example that the particles 6*a* are white in colour and are negatively charged, that the suspension liquid 6*b* is a blue dye solution and that the member 9 and the associated electrode 11 are transparent.

In operation, a voltage +V is applied to the electrode 12 at an end 13 of the apparatus and the opposite end of the electrode i.e. at the opposite end 14 of the apparatus, is held at zero volts thereby causing a potential gradient to be established between the ends 13 and 14 of the apparatus. The electrical equivalent of this first potential gradient is illustrated in FIGURE 3 of the drawings. A control voltage $+V_c$ which has a value between 0 and +V volts, is then applied to the control electrode 11 and because this electrode has a relatively low resistance it will be maintained substantially constant at this potential over the whole of its surface area thereby establishing a second potential gradient between the two electrodes. At some point, between the ends 13 and 14 of the apparatus, for example the point A, the electrode 12 will be at a potential which is equal in value to the applied voltage $V_c$, therefore, the electrode 11 will be positive with respect to the electrode 12 between the point A and the end 14 of the apparatus and the particles 6*a* in this region of the apparatus will be caused to move electrophoretically in the direction of, and be deposited on the surface of, that length of the electrode 11 between the end 14 and the point A. This length of the electrode 11 will, therefore, appear white when viewed in the direction of the arrow 'B'. Between the end 13 of the apparatus and the point A, the electrode 11 will be negative with respect to the electrode 12 and the particles 6*a* in this region of the apparatus will, therefore, be repelled from the electrode 11 and caused to be moved electrophoretically in the direction of, and be deposited on the surface of, that length of the electrode 12 between the end 13 and the point A. This length of the electrode 11 will, therefore, appear blue when viewed in the direction of the arrow 'B'.

Thus, the final appearance of the front electrode when viewed in the direction of the arrow 'B' will be as is illustrated in FIGURE 5 of the drawings for an apparatus which is strip-like in form. The length *l* of the white indication 15 will be proportional to the voltage $V_J$ provided that the resitance, and thus voltage, profile across the electrode 12 is, as is illustrated in FIGURE 4, linear with respect to the length *l*.

Since the indicated reading, i.e. the length *l*, is actually related to the fraction Vc/V, the electrophoretic display apparatus can be used to directly indicate the relative magnitudes of two parameters. With this arrangement the larger of the two parameters would be used to supply the voltage +V and the smaller parameter would be used as the control voltage $+V_c$, the reading on the meter scale will then be proportional to the fraction $V_c/V$. The disaply of absolute values is achieved by using a constant, known, voltage source to supply the voltage +V.

Furthermore, the electrophoretic display can be made to follow almost any 'law' between control voltage and indication by making the resistance profile of the electrode 12 non-linear with repect to the length *l*. For example, by suitable fabrication of the electrode 12, a logarithmically varying control voltage could be made to give a linear reading or vice-versa. Such displays, or displays with expanded scales, could be produced by etching a wedge or other suitable shape in an electrode of uniform resistivity to produce the required non-linear resistance characteristics.

The voltage sensitive display apparatus according to the invention has the advantages that the display has no moving parts and could be fabricated so as to have a depth of less than a quarter of an inch, that it is insensitive to vibration and is comparatively inexpensive to fabricate and that the power requirements are small in relation to an incandescent lamp display.

With the display apparatus according to the invention, the current and power requirements of the electrode 11 which are typically microwatts/sq.cms., are relatively low in comparison to the heavier current required by the 'potential divider' electrode 12. Also, the electrophoretic display apparatus can exhibit a non-volatile memory i.e. the indication is retained in the absence of power, by suitable choice of the electrophoretic suspension medium 6.

It is envisaged that the display apparatus according to the invention will find application in any form of analogue display i.e. thermometers, level indicators, process simulators etc. and could be used to advantage in automobile applications as a cheaper and more robust replacement for fuel gauges, temperature gauges, pressure gauges, ammeters etc., and possibly also for speedometers and tachometers.

It is to be understood that the foregoing description is made by way of example only and is not to be considered as a limitation in its scope.

WHAT WE CLAIM IS:

1. A voltage sensitive display apparatus comprising an electrophoretic suspension medium sandwiched between a first potential dividing electrode and a second control electrode at least one of which is transparent, in which at least the potential dividing elec-

trode is fabricated from a resistive materia and in which terminals are provided for the application of a potential across the resistive material.

2. A voltage sensitive display apparatus as claimed in claim 1 wherein the poential is applied across the potential dividing electrode such that a first potential gradient exists across the resistive material, and a second potential gradient exists between the two electrodes which varies in magnitude and direction along at least a portion of the potential dividing electrode so that the optical characteristics of the electrophoretic suspension medium are altered so as to give a visual indication of the voltage applied to the second control electrode.

3. A voltage sensitive display apparatus as claimed in claim 1 wherein the two electrodes are each mounted on a respective support member and at least one of the electrodes and the associated support member are transparent.

4. A voltage sensitive display apparatus as claimed in any one of the claims 1–3 wherein the display is of a strip-like construction which is relatively narrow in width compared to its length.

5. A voltage sensitive display apparatus as claimed in any one of the preceding claims wherein both of the electrodes are fabricated from a conductive resistive material, wherein he control electrode is of a relatively low eectrical resistance and the potential dividing electrode is of a relatively high electrical resistance and has terminal means at each end thereof between which the first potential gradient can be established.

6. A voltage sensitive display apparatus as claimed in claim 5 wherein the electrical resistance of the potential dividing electrode is in the range 10 to $10^6$ ohms/square.

7. A voltage sensitive display aparatus as claimed in claim 5 or claim 6 when appended to claim 4 wherein the resistance profile of the potential dividing electrode is non-linear along the length thereof.

8. A voltage sensitive display apparatus as claimed in claim 7 wherein the potential dividing electrode is of a material of uniform resistivity and is shaped so as to produce the non-linear resistance profile.

9. A voltage sensitive display apparatus substantially as hereinbefore described with reference to FIGURES 2 to 5 of the drawings accompanying the provisional specification.

10. An analogue display which includes a voltage sensitive display apparatus as claimed in any one of the preceding claims.

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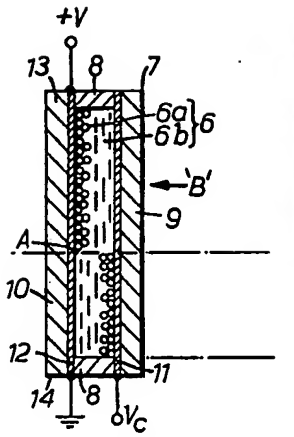


FIG.2.

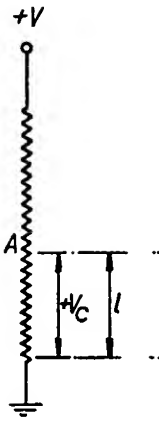


FIG.3.

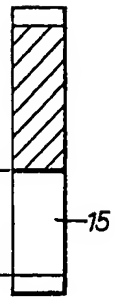


FIG.5.

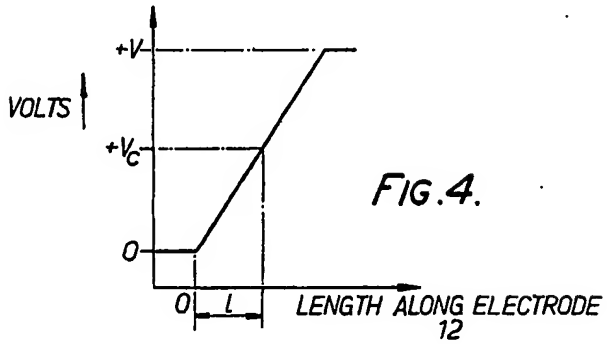


FIG.4.